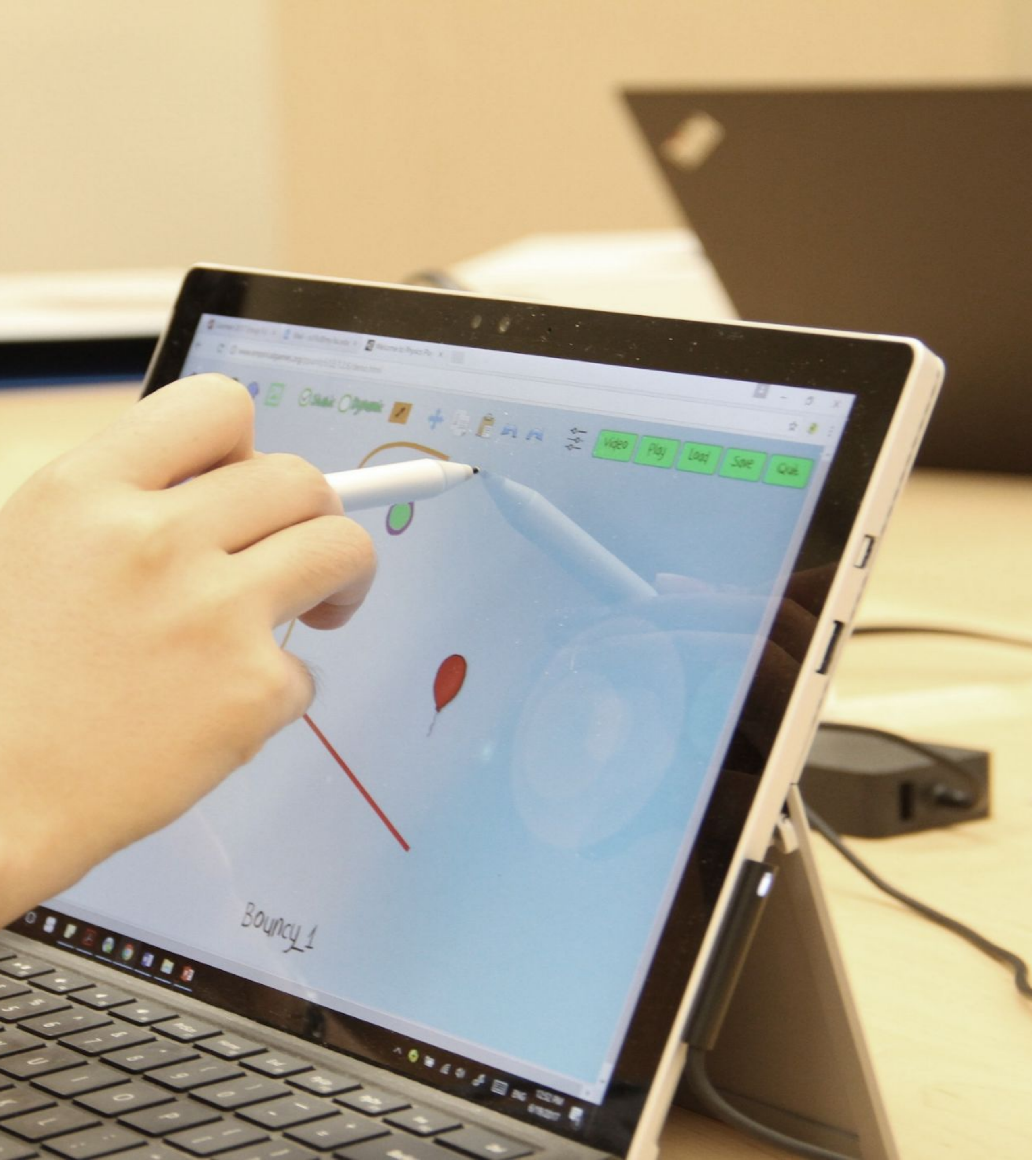

Stealth Assessment in Games to Measure and Support Learning

HKU Center for Information Technology in Education Research Symposium
May 19, 2023

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Florida State University

Games, Learning, Assessment

Claim 1

Good games can act as *transformative environments* to support skill development and deep, meaningful learning.

Claim 2

Learning is best when active, interesting, goal-oriented, and contextualized (i.e., features of good games).

Claim 3

Stealth assessment can collect dynamic evidence of learning in real-time, at various grain sizes (and use info to support learning).


Games

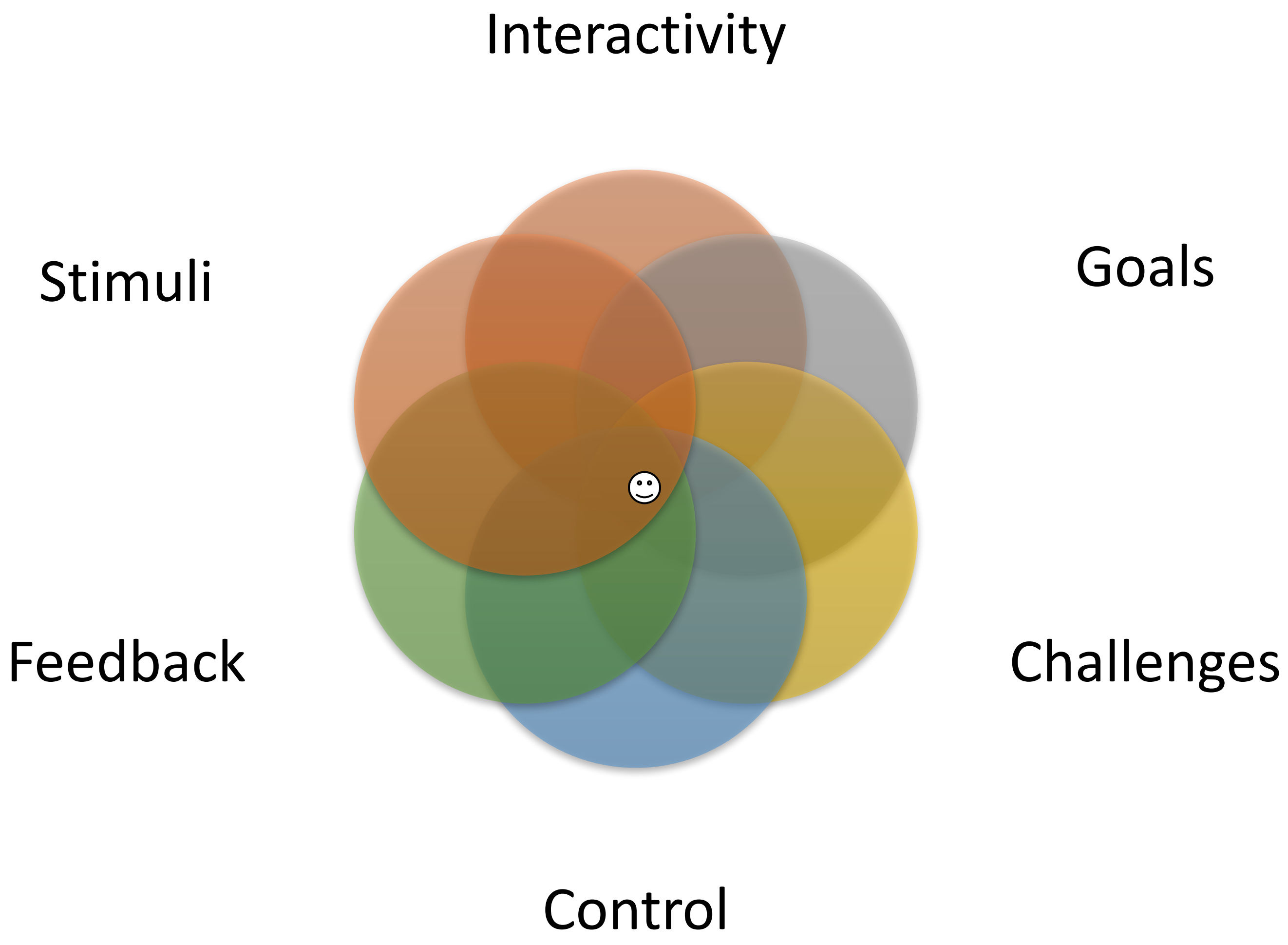
Why Games as Assessment?

1. Good games are *engaging* and require a player to *apply knowledge and skills* to succeed.
2. Games are also *ubiquitous*. 75% of all U.S. households have at least one person who plays video games regularly (ESA, 2020).

Good Game Elements

1. Interactive problem solving
2. Specific goals/rules
3. Adaptive challenges
4. Control
5. Ongoing feedback
6. Sensory Stimuli

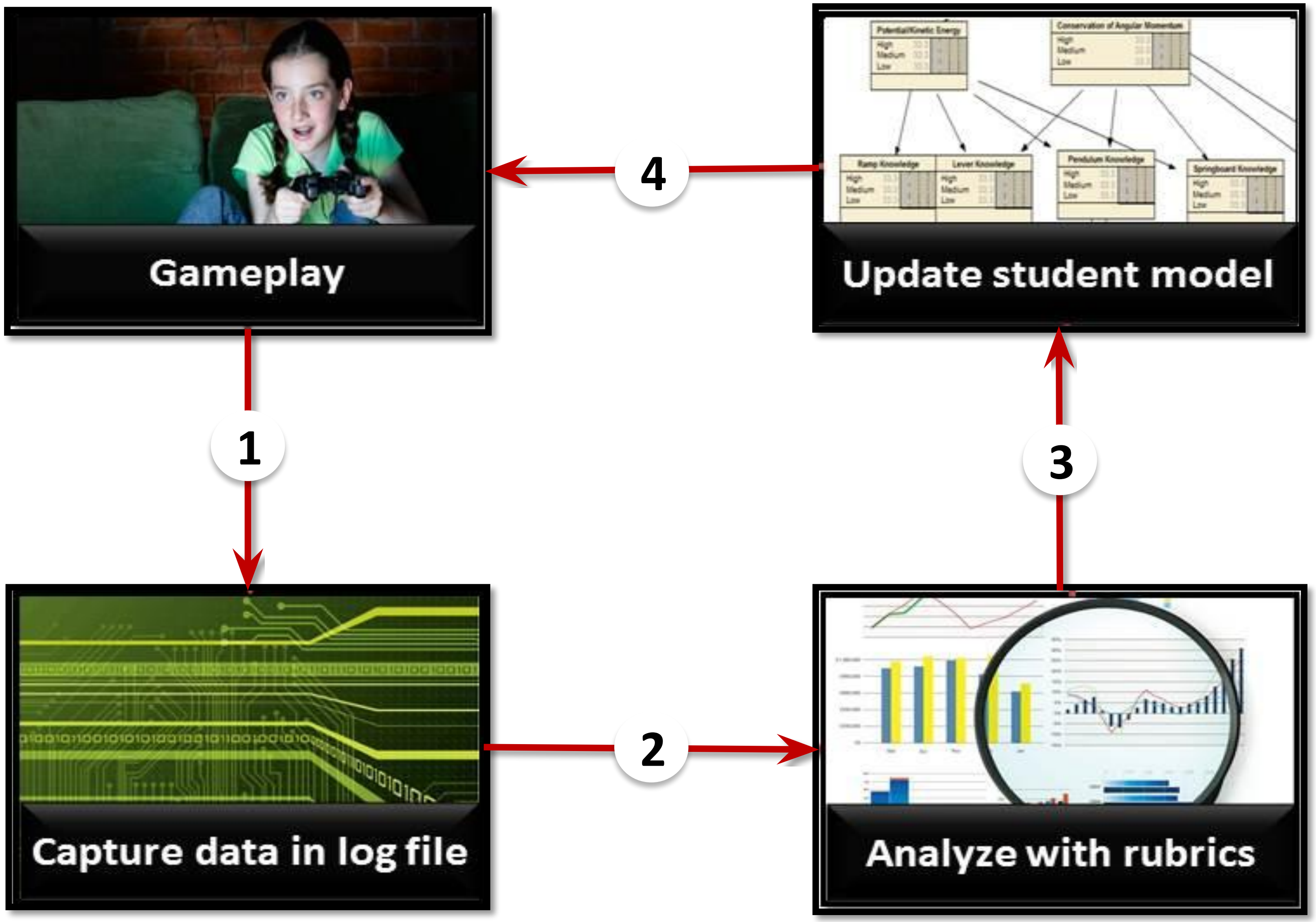
Gestalt of Games



The Hard Part

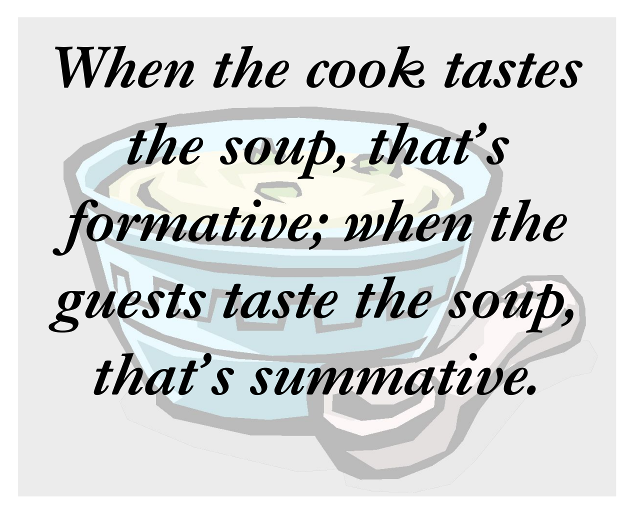
How can we increase learning in games without decreasing the fun?

Stealth Assessment Cycle

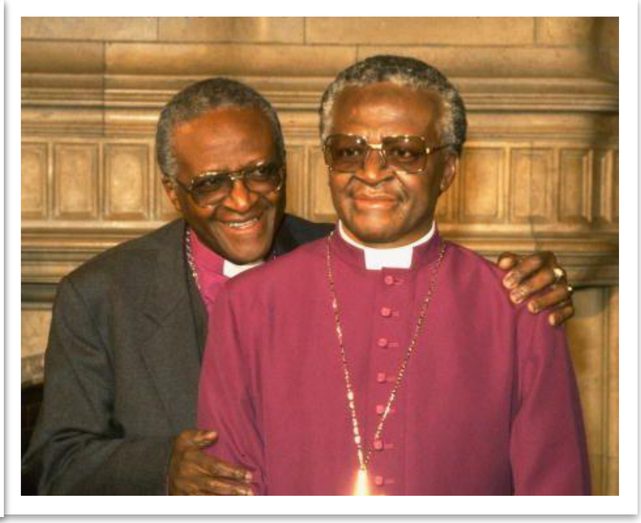


Stealth Assessment Features

Seamless & Ubiquitous



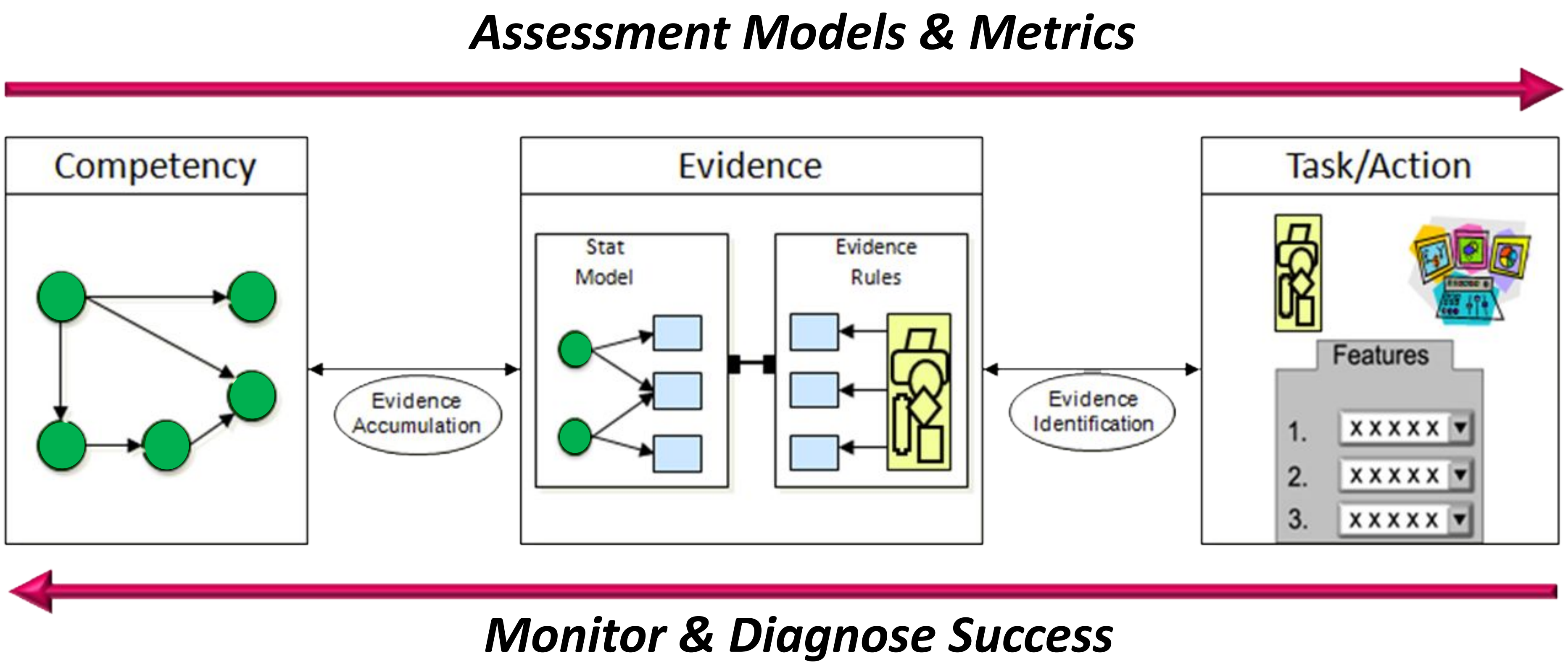
Formative as main purpose



Accurate & Rich Learner Models

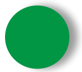
Invisible assessment, transparent support!

Stealth Assessment Models (ECD)



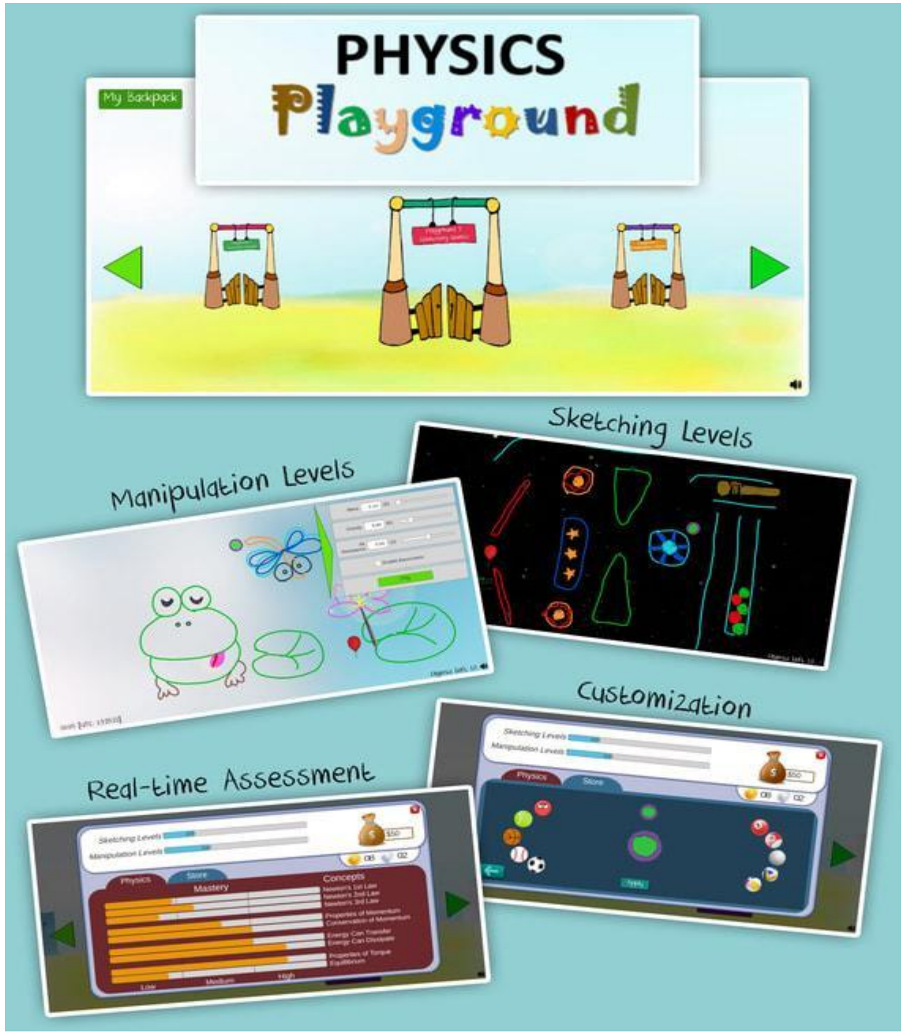
(adapted from Mislevy, Steinberg, & Almond, 2003)

Physics Playground

- ✔ Goal: guide a  to a . Everything obeys basic rules of physics (e.g., gravity, Newton's 3 laws).
- ✔ Two types of levels:

  Sketching: player draws objects that "come to life" (e.g., pendulums, levers)

  Manipulation: player changes physics parameters to solve levels.



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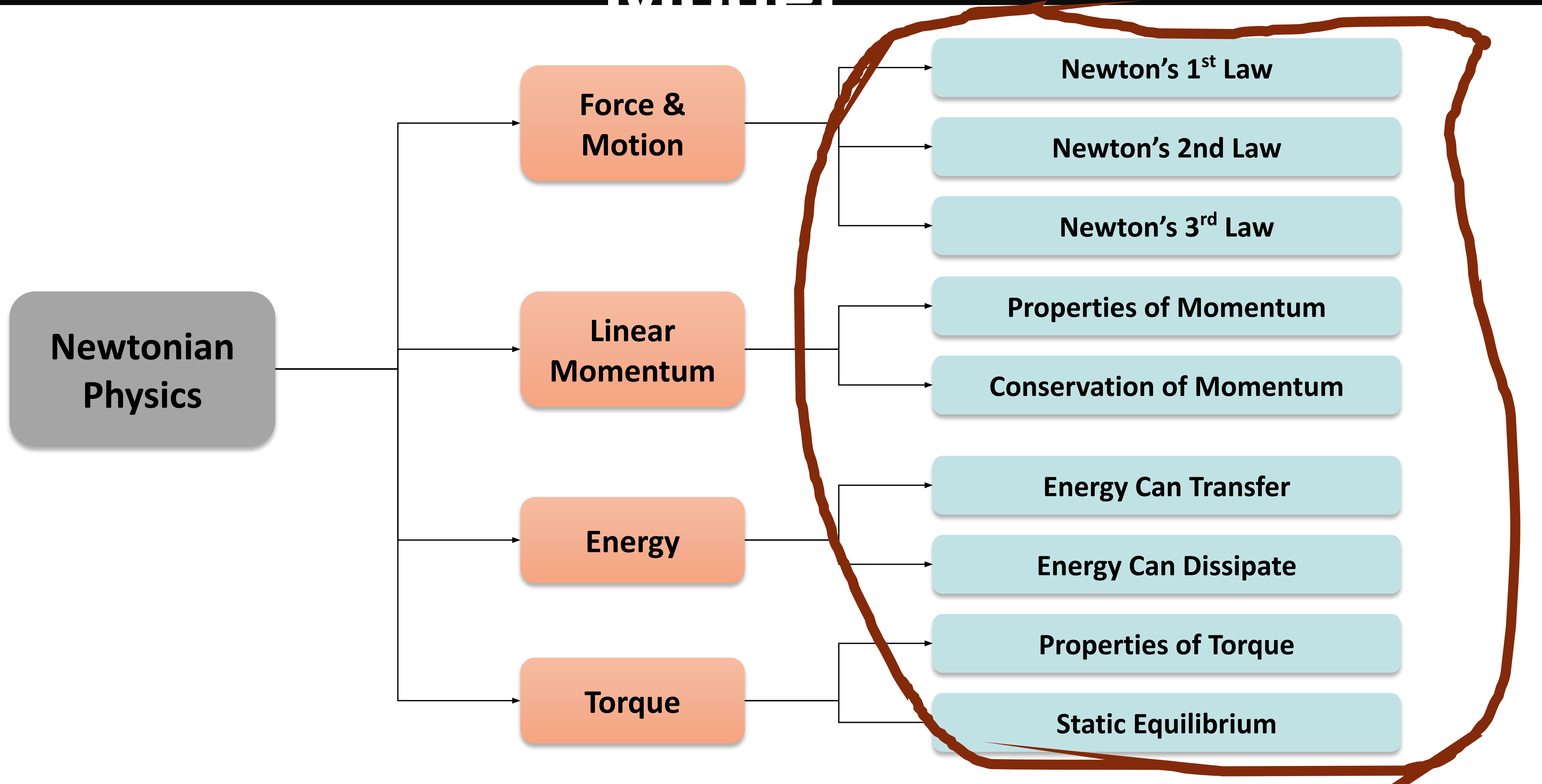
The Team!

Physics Playground Video

Physics Playground—Competency Model



Automated Scoring

Log Snapshot


```
{
    "user_id" : 294,
    "user_fname" : "",
    "user_lname" : "",
    "session_id" : 1,
    "date" : "10\/23\/2012 17:50:14",
    "token" : "51548bf0004b87a169a5f51caa8a27f5",
    "trophies" : "L0-0: 0S 1G,L0-1: 1S 0G,L0-2: 0S 1G,L0-3: 0S 1G,L0-4: 0S 1G,L0-5: 1S 0G",
    "event_count" : 10,
    "event_0" : {
        "type" : 0,
        "type_string" : "Session Start",
        "time_stamp" : 0
    },
    "event_1" : {
        "type" : 3,
        "type_string" : "Enter Room",
        "time_stamp" : 8.264,
        "room_name" : "Playground 1"
    },

    "event_5" : {
        "type" : 2,
        "type_string" : "Play Level",
        "time_stamp" : 195.865997,
        "log_file_name" : "ALEXANDER_294_1_play4.replay",
        "level_path" : ".\\levels\\p0\\4 pendulum.level",
        "game_time" : 62.523998,
        "pause_time" : 0,
        "restart_count" : 1,
        "object_count" : 8,
        "object_limit_count" : 0,
        "nudge_count" : 0,
        "erase_count" : 0,
        "pin_count" : 2,
        "agent_vector" : "18.57 PO S 17600,27.65 PO S 26554,39.23 PO S 38368,59.33 PO S 58256,61.31 PS S 58256",
        "ball_trajectory" : "<1.042, 0.549> <0.972, 0.545> <0.907, 0.564> <0.839, 0.590> <0.765, 0.618> <0.678, 0.651> <0.590, 0.676> <0.491, 0.687> <0.439, 0.691> <0.437, 0.691> <0.436, 0.691>
        "silver" : false,
        "gold" : true,
        "solved" : true
    },
    "event_6" : {
        "type" : 2,
        "type_string" : "Play Level",
        "time_stamp" : 267.790009,
```

Level-level log data


```
"time_stamp": 12.163,
"level_path": ".\\levels\\p4\\diving board.level",
"game_time": 13 149.53,
"pause_time": 1.54,
"restart_count": 2,
"object_count": 14,
"object_limit_count": 1,
"nudge_count": 42,
"erase_count": 13,
"pin_count": 1,
"agent_vector":"61.78 SB, 98.08 SB, 131.60 SB"…
"ball_trajectory": "<0.733, 0.427> <0.766, 0.394>…
"silver": true,
"gold": false,
"solved": true
```

Agent ID system

Agent	Monitor Trigger	Identify Trigger
Ramp	Event Ball touches Primary Object (PO) Conditions • Object has never rotated > 20 degrees	Event Positive ID conditions met OR ball stops touching PO Conditions • Object has never rotated > 20 degrees • Ball moves along object: (>25% in horiz.) OR (>11% horiz. AND >4% vert.) OR (>4% horiz. AND >11% vert.)
Lever	Event Secondary Object falls on Object Conditions • Secondary object has elevated downward momentum (vertical momentum < -.05 kg m/s) • Object has <= 1 pin (attached to static object) • Object has not moved much recently (less than 2% of screen in ⅓ sec)	Event ¾ seconds pass from Monitor Trigger Conditions • Object has touched ball since Monitor Trigger • Object has rotated > 20 degrees since Monitor Trigger • Ball has reached an apex 4% higher than at Monitor Trigger
Pendulum Strike	Event Object touches ball Conditions • Object has 1 pin • Object has rotated > 20 degrees • Object has non-zero rotational velocity	Event ¾ seconds pass from Monitor Trigger Condition • Ball moved moderately since Monitor Trigger (> 15% screen)
Springboard	Event Object has elevated rotational velocity (>1.5 m/s) Conditions • Rotating toward 12 o'clock (as opposed to 6 o'clock) • Object has 2+ pins (attaches to a static object)	Event ¾ seconds pass from Monitor Trigger Conditions • Object has touched ball since Monitor Trigger • Ball has reached an apex 6% higher than at Monitor Trigger

Agent ID system

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Agent ID system

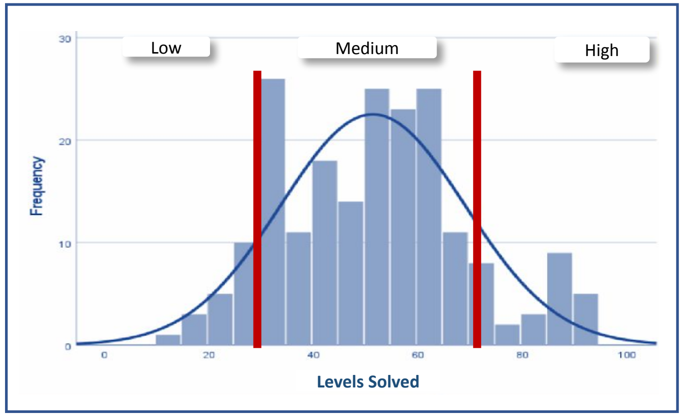
Agent	Monitor Trigger	Identify Trigger
Pendulum Strike	Event Object touches ball Conditions • Object has 1 pin • Object has rotated > 20 degrees • Object has non-zero rotational velocity	Event ¾ seconds pass from Monitor Trigger Condition • Ball moved moderately since Monitor Trigger (> 15% screen)

PP—Evidence Model

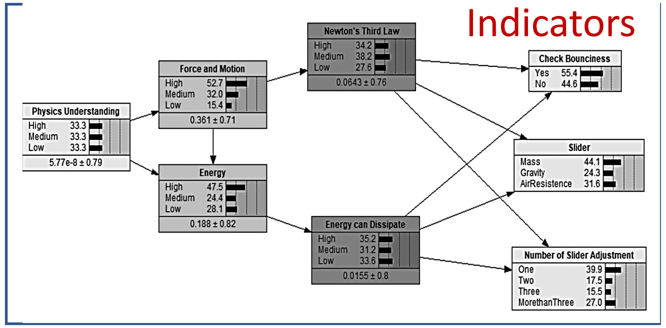
- **Evidence Identification** (EI): Establish rubrics to auto-score raw data (observables, aka “indicators”) per level from log files.

Time to solve, object(s) drawn, sliders adjusted, # restarts, gold coin, levels solved, etc. (by level & session).

- **Cut Scores**: Determine cut scores from frequency distributions of indicators.



- **Evidence Accumulation** (EA): During gameplay, data per indicator feeds into Bayes net (*one BN per level*).



For more, see R. Almond’s Peanut suite of tools to generate BNs (https://pluto.coe.fsu.edu/RNetica).

Stealth Assessment Steps

Stealth Assessment Steps

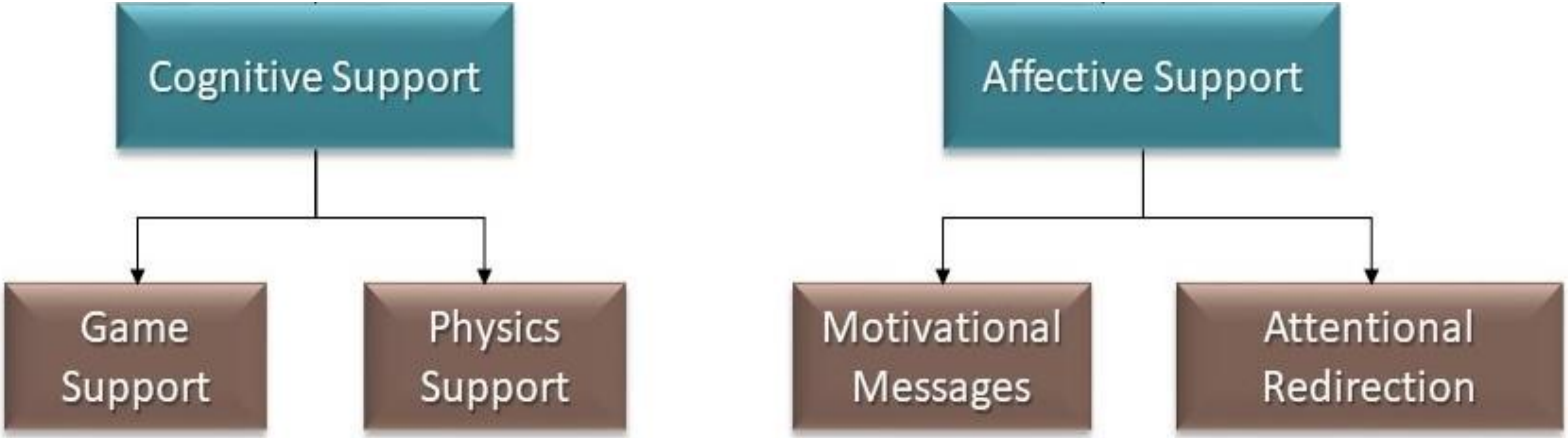
1. Develop Competency Model (CM)
2. Select (or design) game to embed asst.
3. List indicators (evidence to inform CM)
4. Develop new tasks in game, if necessary
5. Setup Q-matrix (link indicators to CM facets)

Stealth Assessment Steps (cont.)

Stealth Assessment Steps

6. Determine “scoring rules” for indicators (the EM)
7. Set statistical relations (indicators & CM var’s)
8. Pilot test BNs and modify parameters
9. Validate stealth asst. with external measures
10. Use asst. data for feedback and learning support

Learning Supports



- Worked examples
- Game tutorial
- Hints
- Support tutorial

- Physics videos
- Interactive def’s
- Animations
- Formulas
- Hewitt videos
- Glossary

- Encouragement
- Growth mindset
- Praise

- Breathing exercise
- Store—change ball, music, background
- Rube Goldberg videos

Learning Supports

Cognitive Support

Game Support

- Worked examples
- Game tutorial
- Hints
- Support tutorial

Physics Support

- Physics videos
- Interactive def's
- Animations
- Formulas
- Hewitt videos
- Glossary

Affective Support

Motivational Messages

- Encouragement
- Growth mindset
- Praise

Attentional Redirection

- Breathing exercise
- Store—change ball, music, background
- Rube Goldberg videos

Learning Supports—Physics videos

Energy can Transfer

(Lever)

Research Study

- N = 263 (9^{th} - 11^{th} graders), science class, 6 days with ~4 hr gameplay
- Sketching and manipulation levels (91 levels total)
- Full set of (8 different) learning supports
- Physics pretest and posttest
- Game and learning support questionnaire

For details, see: https://myweb.fsu.edu/vshute/pdf/JCAL2020.pdf

Research Questions

RQ1 ***Psychometric qualities***. Are stealth assessment measures *reliable, valid, and fair?*

RQ2 ***Learning & enjoyment***. Do kids, overall, *learn* physics from PP? Did they *enjoy* the game?

RQ3 ***Learning supports***. Which *learning supports* most effectively enhance learning and game performance?

RQ1

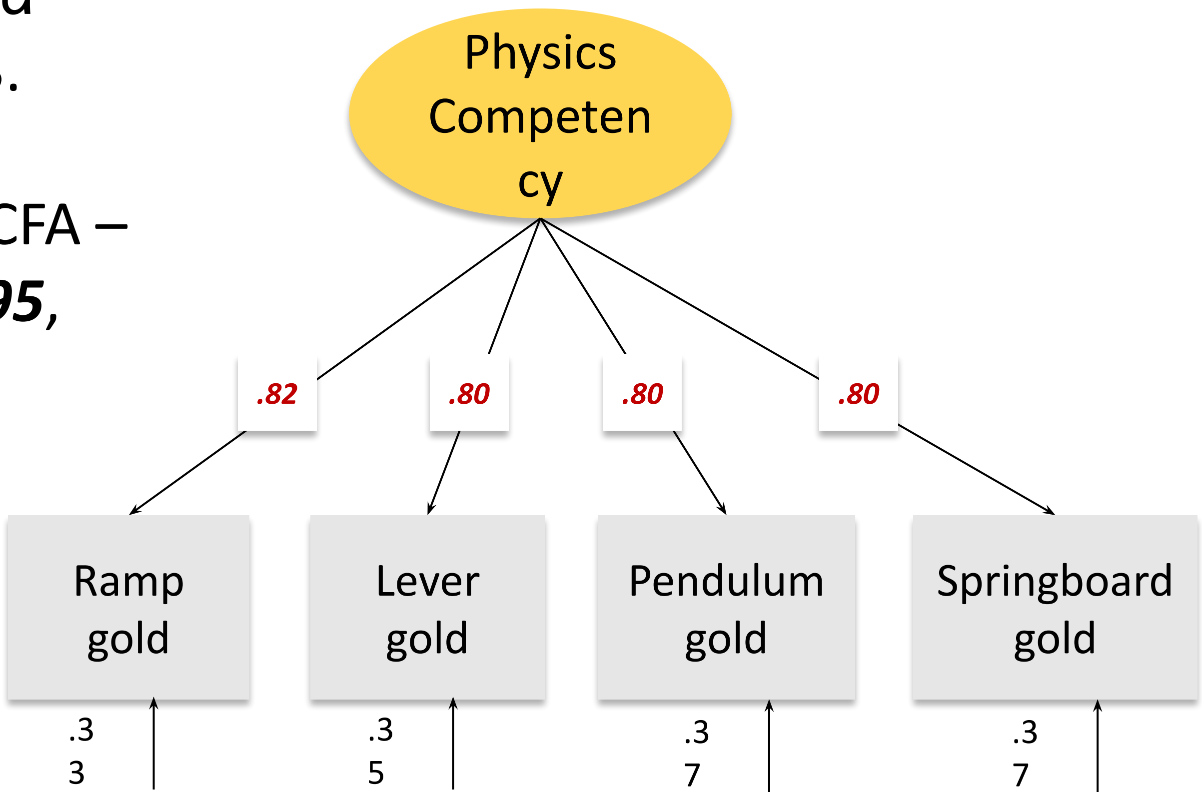
Reliability (n = 263)

1. *Reliability of external measure*: (Cronbach's *α* values), *pretest* = .77; *posttest* = .82; *n* = 263.

2. *Reliability of stealth assessment measures:* CFA – Gold coins by four agents: X^2/df < 3, ***CFI > .95***, ***RMSEA < .05***, SRMR < .05

3. *Intraclass correlation* = ***.85*** (Ramp, Lever, Pendulum, Springboard gold coins)

4. *Cronbach's α of stealth assessment* = ***.87***
   (Data: gold coin info (NA, 0, 1);
   Valid Cases: 110 (out of 169); Levels: 29 (out of 74)



RQ1

Validity

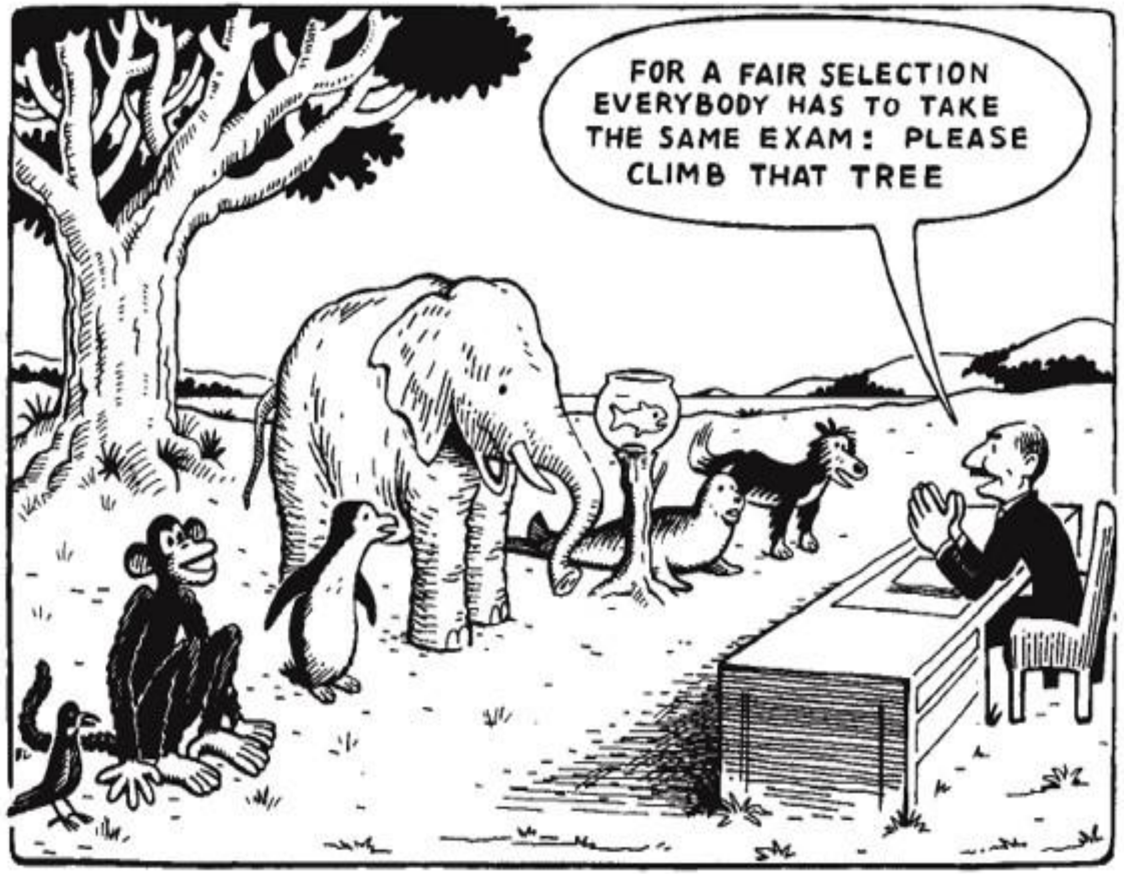
	Stealth Ass't Estimates	Pretest	Posttest
	Physics (Overall) EAP	0.36**	0.40**
Physics Facets	Force and Motion	0.29**	0.30**
	Linear Momentum	0.27**	0.27**
	Energy	0.22**	0.35**
	Torque	0.14*	0.18**

Note. * $p < .05$; ** $p < .01$

RQ1

Fairness (re: learning)

Same number of males and females with wide range of ethnicities.



Learning by Gender. ANCOVA: post (DV), gender (IV), pre (Cov): Results showed *no significant outcome differences by gender* holding pretest constant: $F(1, 195) = 0.04$; $p = .85$.

Learning by Ethnicity. ANCOVA: post (DV), ethnicity (IV), pre (Cov): Results showed *no significant outcome differences by ethnicity* holding pretest constant: $F(2, 154) = 1.32$; $p = .27$.

RQ2

Learning & Enjoyment

- ***Overall Learning***. Students scored significantly higher on posttest than pretest: $F(1, 198) = 9.53$; $p = .002$ after gameplay. Control group (no game) showed no pre/post diff ($M_{pre} = 11.6$; $M_{post} = 11.6$).
- ***Overall Enjoyment***. Students really enjoyed the game ($M = 4.03$) on a 1-5 scale (1=hated; 5=loved).
  - By Gender: Males ($M = 4.05$) and females ($M = 4.00$) enjoyed it equally!
  - By Ethnicity: Whites ($M = 4.0$), Blacks ($M = 4.0$), and Hispanics ($M = 4.3$) enjoyed it equally!

RQ3

Learning Supports

- ***Favorite supports***. Hints, physics videos, and worked examples.
- ***Predicting learning***. Regression: Posttest (DV), with pretest & all 8 support freqs in equation: Only pretest (β = .66) and Physics videos (β = .11) significantly predicted outcome: R^2 = .50; F (2, 198) = 97.6 (p < .001)
- ***Predicting gameplay***. Those watching more Physics videos also did significantly better in the game than those watching fewer videos (re: levels completed, gold, and silver coins earned).
- ***Supports don't detract from fun***. Students who watched more Physics videos reported ***higher*** levels of enjoyment than watching fewer. Enjoyment (β = .18, $F(1, 193) = 6.23$, p = .01).

Bonus Question!

Can stealth assessment be used in *existing* games to measure students' abilities?

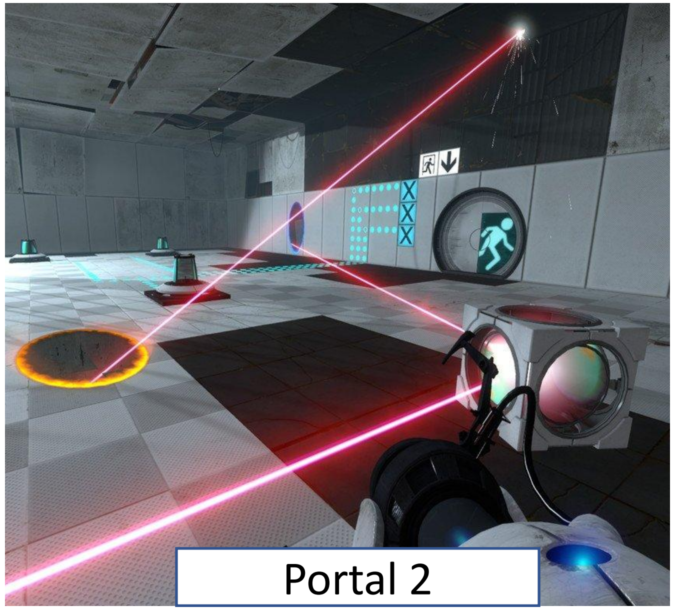
Stealth Assessment in Commercial Games

- 1st stealth assessment (proof of concept)
- Measured ***creative problem-solving skills***
- Merged cog & non-cog variables
- Used Bayes nets to accumulate estimates
- Shute et al. (2009). Melding the power of serious games and embedded assessment to monitor and foster learning: Flow and grow.

- Love this game!
- Measured ***problem-solving skills***
- Used Bayes nets to accumulate estimates
- Validated stealth assessment to external measures
- Shute, et al. (2016). Measuring problem solving skills via stealth assessment in an engaging video game.

Stealth Assessment in Commercial Games

- Measured ***calculus knowledge***
- Validated the stealth asst measure.
- Smith, G., Shute, V. J., & Muenzenberger, A. (2019). Designing and validating a stealth assessment for calculus competencies.



- Measured ***problem solving, spatial skill, & persistence*** before/after game <compared to Lumosity>
- Shute, V. J., Ventura, M., & Ke, F. (2015). The power of play: The effects of Portal 2 and Lumosity on cognitive and noncognitive skills.

- Measured prob solving, causal reasoning, static equilibrium.
- Qualitative study supporting importance of failure re: learning.
- See: Shute, V. J., & Kim, Y. J. (2011). Does playing the World of Goo facilitate learning?.

LESSON LEARNED—*Stealth assessment can be included in existing commercial games to measure important competencies!*

Current & Next Steps

- **Student vs. Computer Control of Supports.** Recently tested student vs. computer-delivery of supports on learning/engagement (IES). When optional, students don't get enough dosage so default now = computer delivered.
- **Timing of Support Delivery.** Should supports be delivered **before** a relevant game level (e.g., advance organizer) or **after** (for reflection & consolidation)? Currently tested 146 Ss with slight advantage for *after* (see: https://myweb.fsu.edu/vshute/pdf/TIMING.pdf).
- **Affective Supports.** Designed/developed/tested multiple affective supports to reduce frustration and increase persistence (e.g., music change, fun videos, motiv messages, mindfulness, secret store) (https://myweb.fsu.edu/vshute/pdf/affect_support.pdf)
- **Implement quit prediction model in the game.** Who is likely to quit a level? The model features 37 behavioral indicators with different weights. Will test the quit model in PP to trigger affective supports (https://myweb.fsu.edu/vshute/pdf/ICQE_PP_Quit.pdf).

Take-aways!

1. **(Most) everything is teachable.** Some things we didn't think could be instructed (e.g., spatial ability, creativity, empathy, collaborative problem solving, persistence, etc.) can be! So, after perfecting meas't of competencies, focus on interventions to improve learning.
2. **Feedback**. One of the most important parts of learning anything is feedback! But the type and timing of feedback used is key. More research is needed here.
3. **Make learning fun**. Test anxiety is real, engagement leads to learning, and current standardized tests are limited. Consider using games (or engaging immersive environments) to measure & support targeted competencies!
4. **Theoretical foundation is key**. For both measurement and support of learning, develop CMs at the outset, then associated "learning indicators" (evidence) and real-time scoring/updating methods (e.g., ECD for top-down approach). Later, exploratory methods can find additional learning indicators (e.g., EDM). Together these can support of learning.

Take-aways!

- 5 **Bayesian networks**. The most effective way to measure/estimate (in real time) competency states at various grain sizes is via Bayes nets (I've used them since 1995). Measurements should be probabilistic & cumulative, not black/white (pass/fail). May use tallies, which are simpler.
- 6 **Psychometric qualities**. Talk is cheap. Always validate your instruments if you want to make solid claims about learning!
- 7 **Embrace principles of instruction & learning.** When designing learning supports in games/engaging environments, make sure to pay attention to first principles of instruction (Merrill), multimedia (Mayer), and motivation (Keller)!

Thank you!

Questions?

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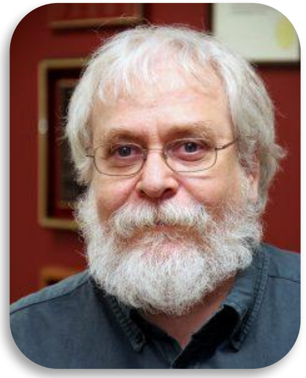
Website:

If we think of our children as plants... summative assessment of the plants is the process of simply measuring them. The measurements might be interesting to compare and analyze, but, in themselves, they do not affect the growth of the plants. On the other hand, formative assessment is the garden equivalent of feeding and watering the plants – directly affecting

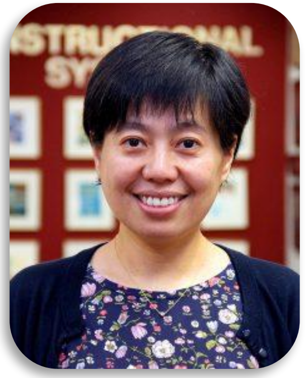
Our Team!

PI

Co-PI

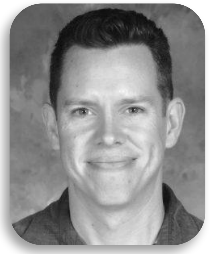


Co-PI



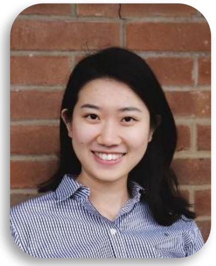
Co-PI

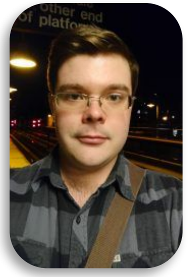
Co-PI



SMEs

Former RAs, now Profs

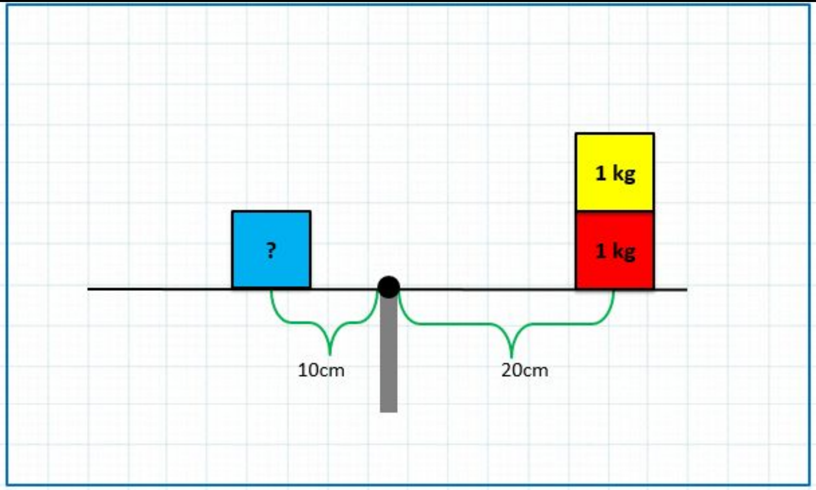




RAs

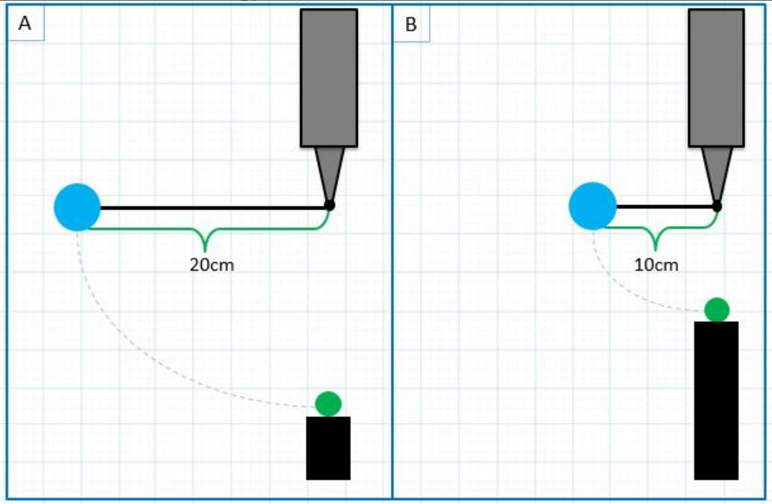
2016 – 2021

Physics Test (examples)



Three blocks are placed on the scale. The yellow and red blocks have the same mass. If the lever is balanced, what is the mass of the blue block?

a) 1 kg
b) 2 kg
c) 3 kg
d) 4 kg

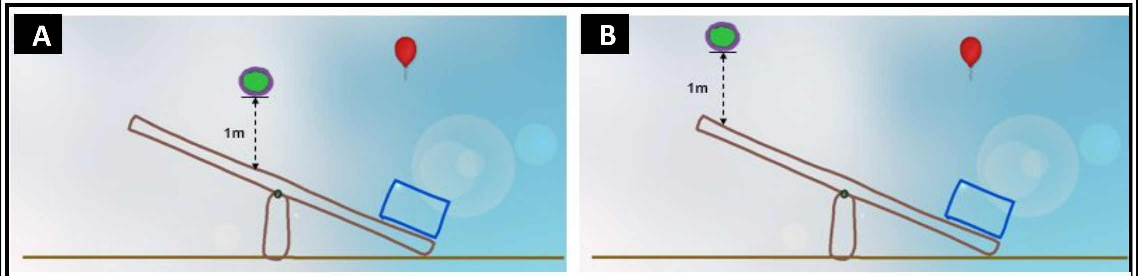


In Figures A and B, the pendulums have different lengths but the same mass. They are released at the same time. Which pendulum will travel faster *just before* it impacts with the green ball?

a) A and B will move at the same speed.
b) B will be faster than A.
c) A will be faster than B.
d) More information is needed to answer the question.

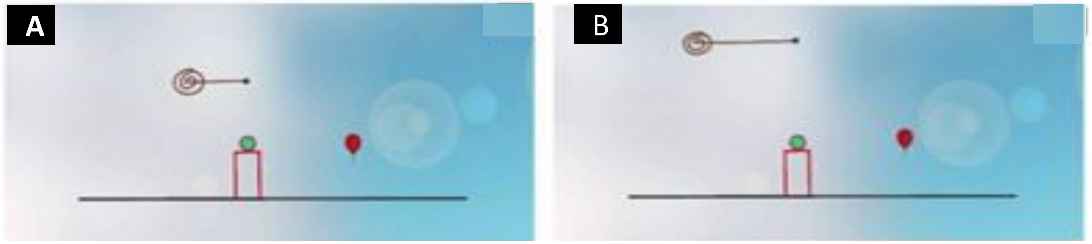
Get Back!

Physics Test (near transfer)



In which picture (A or B) will the blue box bounce higher?

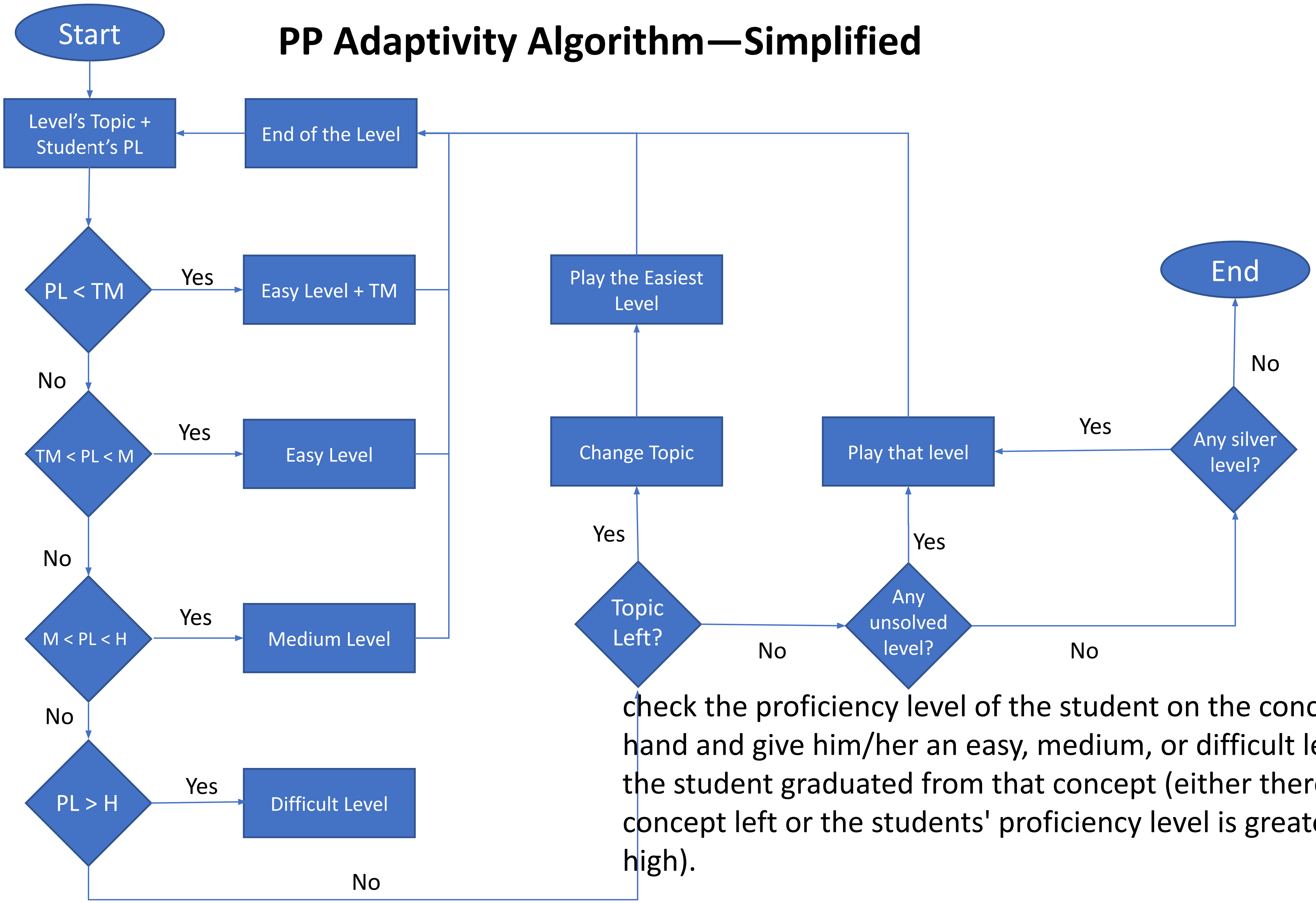
- A
- B
- Both will reach the same height
- Not enough information



Both pendulums will hit the green ball. Which pendulum would you choose to solve this level (get the green ball to hit the red balloon)?

- A
- B
- No difference
- Not enough information

PP Adaptivity Algorithm—Simplified

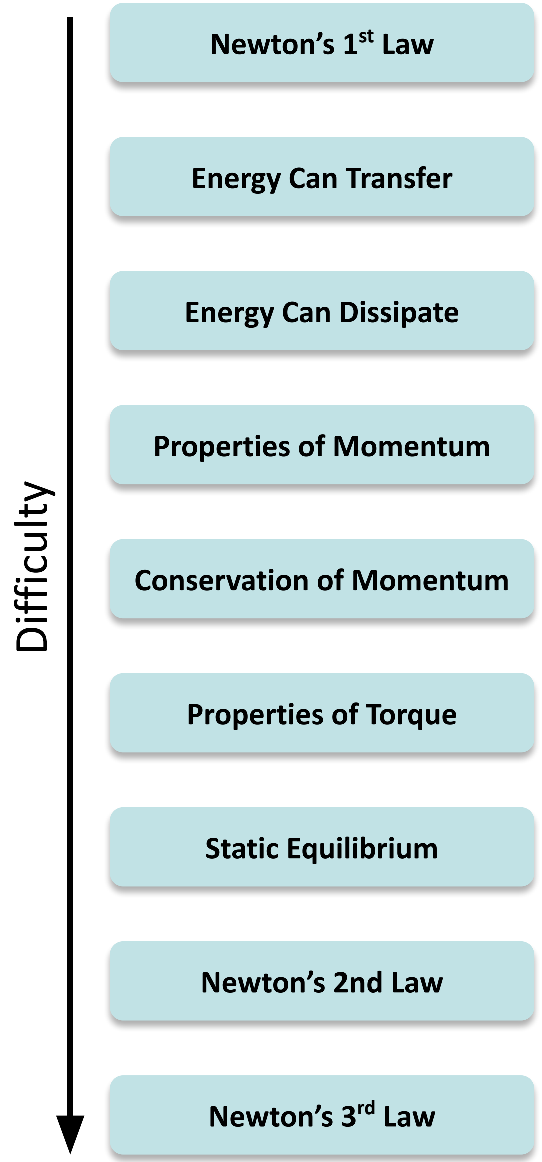


check the proficiency level of the student on the concept at hand and give him/her an easy, medium, or difficult level until the student graduated from that concept (either there is no concept left or the students' proficiency level is greater than high).

Physics Playground—4 Conditions

Concepts arrayed by difficulty. Within a concept, levels differed by difficulty (combined game mechanics and physics). All Ss completed tutorials for both Sketching and Manipulation types. About 10 levels for each of the 9 concepts.

- **Linear** (lockstep order): <N1L> Levels 1, 2, 3, … 10; <EcT> Levels 11, 12… 21; …
- **Adaptive** (based on BN estimates): <N1L> Levels 1, 4, 10; <EcT> Levels 11, 13, 18 ….
- **Nonlinear**: (free choice): <N1L> Level 1; <N3L> Level 80; <PoM> Level 35 …
- **Control**: pretest and posttest only (no game).



RQ2

Learning

Learning by Condition*.** ANCOVA with posttest as DV, condition as IV, and pretest as covariate showed ***no significant outcome differences by condition, holding pretest constant: $F(2, 195) = 0.34$; $p = .71$.

Condition	Pretest M (SD)	Posttest M (SD)
Adaptive (*n* = 64)	11.77 (3.4)	12.23 (3.7) Gain = 0 .46
Linear (*n* = 68)	11.82 (3.4)	12.41 (4.0) Gain = 0 .59
Nonlinear (*n* = 67)	11.88 (3.8)	12.72 (3.9) Gain = 0 .84
Control (*n* = 64)	11.61 (3.6)	11.60 (4.2) Gain = -0 .01

RQ3

Learning Supports

- ***Favorite supports***. Hints, physics videos, and worked examples.
- ***Predicting learning***. Regression: Posttest (DV), with pretest & all 8 support freqs in equation: Only pretest (β = .66) and Physics videos (β = .11) significantly predicted outcome: R^2 = .50; F (2, 198) = 97.6 (p < .001)
- ***Dosage***. Students who watched more Physics videos learned significantly more physics and did better in the game than those who watched fewer animations (for DV's: posttest, levels completed, gold, and silver coins earned).
- ***Supports don't detract from fun***. Students who watched more Physics videos reported ***higher*** levels of enjoyment than watching fewer. Enjoyment (β = .18, F(1, 193) = 6.23, p = .01).

- Posttest (holding pre constant): ($\beta = .11$; $t = 2.11$, $p = .04$, $R^2 = .50$).
- Levels completed ($\beta = .43$, $F(1, 197) = 45.15$, $p < .001$, $R^2 = .18$),
- Gold coins earned ($\beta = .35$, $F(1, 197) = 27.84$, $p < .001$, $R^2 = .12$)
- Silver coins earned ($\beta = .31$, $F(1, 197) = 21.42$, $p < .001$, $R^2 = .10$).

Expected A Posteriori (EAP)

- For every node in physics CM, there's a triplet of current estimates: *p*(High), *p*(Medium), *p*(Low) with values summing to 1.
- To get a single number from triplets, we can assign weights (e.g., +1 * *p*(H); 0 * *p*(M); -1 * *p*(L)) which reduces to *p*(H) – *p*(L).
- EAPs range from -1 to +1 like correlations.

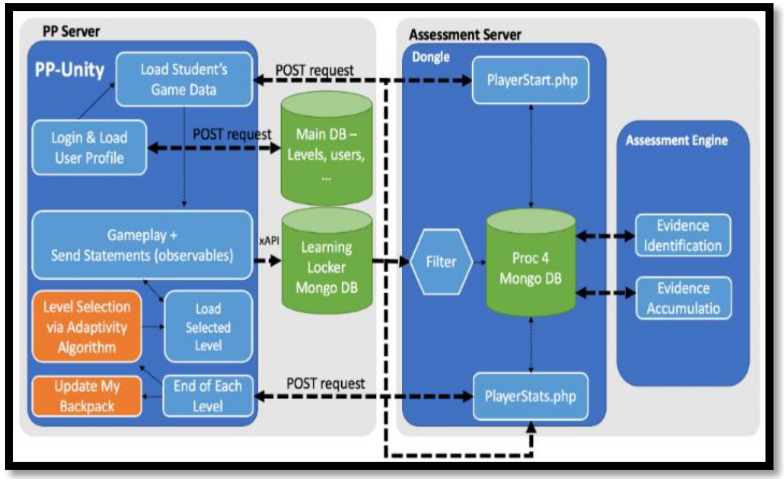
Get Back!

Augmented Q-Matrix □ Bayes nets

1. **Q-matrix**: Set up relations among all levels (> 150), their targeted physics concept, difficulty, etc.
2. **Indicators**: Specify "indicators" (measurable behaviors in the game) per task type (sketching vs. manipulation)
3. **Evidence Identification** (EI): Establish rubrics to automatically score raw data per level from log files (e.g., number restarts, gold trophy <0/1>).
4. **Cut Scores**: Determine cut scores from frequency distributions of raw observables.
5. **Evidence Accumulation** (EA): For each indicator, create Low, Med, High levels to feed into Bayes net.
6. **Generation of BNs**. Used Almond's Peanut suite of tools to generate BNs (https://pluto.coe.fsu.edu/RNetica).

(not expected to be viewable)

	can be solved by:	Newton's 1st Law	Newton's 2nd Law	Newton's 3rd Law	Properties of Momentum	Conservation of Linear Momentum	Energy can Transfer	Energy can Dissipate	Properties of Torque	Equilibrium	Iterative Design	GM (1-5)	PU (1-5)	Composite Difficulty Score	Term
Balance	Manipulation	2	1	0	0	0	0	0	0	0		4	1	5	force
Blocked by Blocks	Manipulation	0	1	0	0	0	2	0	0	0		3	2	5	dissipative force
Break the maze	Manipulation	0	2	0	1	0	0	0	0	0		3	2	5	N 1st L
Broken Guitar	Manipulation	0	2	0	1	0	0	0	0	0		2	2	4	momentum
Cookie Monster	Manipulation	0	2	1	0	0	0	0	0	0		2	1	3	free-fall
Dominos	Manipulation	0	0	0	0	0	2	1	0	0		1	2	3	dissipative force
Fireworks	Manipulation	0	0	1	0	0	0	2	0	0		4	2	6	energy can dissipate
Florida	Manipulation	0	0	2	0	0	0	1	0	0		2	2	4	dissipative force
Frog	Manipulation	0	0	2	0	0	0	1	0	0		3	2	5	N 3rd L
Lighthouse	Manipulation	1	0	2	0	0	0	0	0	0		3	1	4	N 3rd L
Lollipop	Manipulation	0	0	0	0	0	0	0	2	1		3	3	6	equilibrium
Mobile	Manipulation	0	0	0	0	0	0	0	2	1		2	3	5	equilibrium
Plum Blossom	Manipulation	1	2	0	0	0	0	0	0	0		2	1	3	force
Shelves	Manipulation	0	0	0	2	0	1	0	0	0		2	3	5	torque
Skate Park	Manipulation	0	0	0	0	0	2	1	0	0		1	2	3	dissipative force
Socks	Manipulation	0	2	0	0	0	0	1	0	0		2	2	4	velocity
Spring	Manipulation	2	0	0	1	0	0	0	0	0		2	2	4	inertia
Tricks	Manipulation	0	0	0	0	0	0	2	0	1		2	4	6	acceleration
UFO2	Manipulation	1	0	2	0	0	0	0	0	0		2	1	3	coefficient of restitution
Whale	Manipulation	2	0	0	0	0	0	1	0	0		3	2	5	energy can dissipate
Around the Tree (P3)	R	1	0	0	0	0	2	0	0	0		2	2	4	GPE
Cosmic Cave (P6.11)	L/SB	0	0	0	0	0	2	0	1	0		4	4	8	N 2nd L
Downhill (P2)	R	1	0	0	0	0	2	0	0	0		1	2	3	N 1st L
Green Appple (prev Torque)	Sketching	0	0	0	0	0	0	0	1	2		3	3	6	mass
Heavy Blocks (P4)	L/P	1	0	0	0	0	0	0	2	0		3	2	5	kinematics
Little Mermaid (P3)	SB	0	0	0	0	0	1	0	0	0		2	2	4	energy can transfer
Nature (P7)	L	0	0	0	0	0	2	0	1	0		5	4	9	ME



Augmented Q-Matrix

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1		can be solved by:	Newton's 1st Law	Newton's 2nd Law	Newton's 3rd Law	Properties of Momentum	Conservation of Linear Momentum	Energy can Transfer	Energy can Dissipate	Properties of Torque	Equilibrium	Iterative Design	GM (1-5)	PU (1-5)	Composite Difficulty Score	Term			
2	Balance	Manipulation	2	1	0	0	0	0	0	0	0		4	1	5	force			
3	Blocked by Blocks	Manipulation	0	1	0	0	0	2	0	0	0		3	2	5	dissipative force			
4	Break the maze	Manipulation	0	2	0	1	0	0	0	0	0		3	2	5	N 1st L			
5	Broken Guitar	Manipulation	0	2	0	1	0	0	0	0	0		2	2	4	momentum			
6	Cookie Monster	Manipulation	0	2	1	0	0	0	0	0	0		2	1	3	free-fall			
7	Dominos	Manipulation	0	0	0	0	0	2	1	0	0		1	2	3	dissipative force			
8	Fireworks	Manipulation	0	0	1	0	0	0	2	0	0		4	2	6	energy can dissipate			
9	Florida	Manipulation	0	0	2	0	0	0	1	0	0		2	2	4	dissipative force			
10	Frog	Manipulation	0	0	2	0	0	0	1	0	0		3	2	5	N 3rd L			
11	Lighthouse	Manipulation	1	0	2	0	0	0	0	0	0		3	1	4	N 3rd L			
12	Lollipop	Manipulation	0	0	0	0	0	0	0	2	1		3	3	6	equilibrium			
13	Mobile	Manipulation	0	0	0	0	0	0	0	2	1		2	3	5	equilibrium			
14	Plum Blossom	Manipulation	1	2	0	0	0	0	0	0	0		2	1	3	force			
15	Shelves	Manipulation	0	0	0	2	0	1	0	0	0		2	3	5	torque			
16	Skate Park	Manipulation	0	0	0	0	0	2	1	0	0		1	2	3	dissipative force			
17	Socks	Manipulation	0	2	0	0	0	0	1	0	0		2	2	4	velocity			
18	Spring	Manipulation	2	0	0	1	0	0	0	0	0		2	2	4	inertia			
19	Tricks	Manipulation	0	0	0	0	0	0	2	0	1		2	4	6	acceleration			
20	UFO2	Manipulation	1	0	2	0	0	0	0	0	0		2	1	3	coefficient of restitution			
21	Whale	Manipulation	2	0	0	0	0	0	1	0	0		3	2	5	energy can dissipate			
22																			
23	Around the Tree (P3)	R	1	0	0	0	0	2	0	0	0		2	2	4	GPE			
24	Cosmic Cave (P6.11)	L/SB	0	0	0	0	0	2	0	1	0		4	4	8	N 2nd L			
25	Downhill (P2)	R	1	0	0	0	0	2	0	0	0		1	2	3	N 1st L			
26	Green Appple (prev Torque)	Sketching	0	0	0	0	0	0	0	1	2		3	3	6	mass			
27	Heavy Blocks (P4)	L/P	1	0	0	0	0	0	0	2	0		3	2	5	kinematics			

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